

# *Regional Climate Simulations within Ouranos*

**Daniel Caya**

*Directeur, Simulations climatiques*

- The Ouranos Consortium
- Regional Climate Simulations
- First results
- Planned activities 2004 - 2009



*Consortium sur la climatologie  
régionale et  
l'adaptation aux changements  
climatiques*

# **The Ouranos Consortium : Unique in Canada**



550 Sherbrooke West  
Montréal  
(near UQÀM, McGill, INRS, HQ ...) 18<sup>th</sup> and 19<sup>th</sup> floors, 1800 m<sup>2</sup>

- Coordination of interdisciplinary research
- 90 scientists and professionals working together at the same location
- Access to an extensive network of experts, users and true stakeholders
- Dedicated supercomputer for climate simulations:
  - SGI-3600: 32 CPU
  - CRAY SX-6: > 0,1 TFLOPS sustained (early 2004)
  - 125 Tbytes storage
- 6 M\$ annual base budget (13 M\$ with leverage)



**More than 150 scientists at work on 14 programs, 45 projects in:**

- Climate Science
- Support to Adaptation Decision



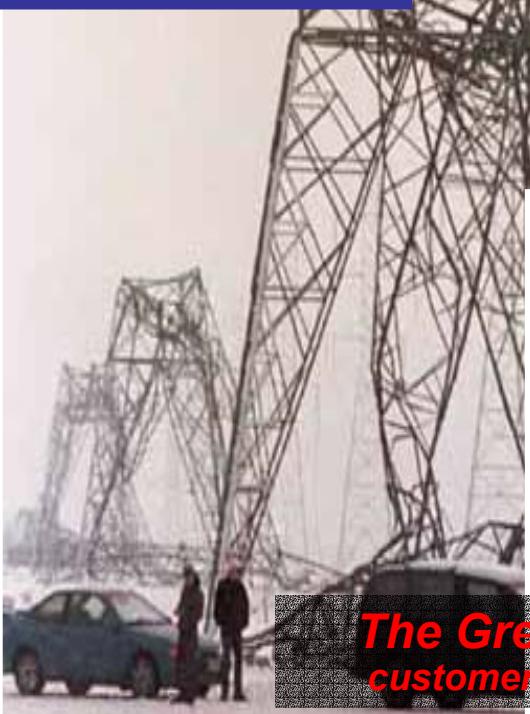
# The "Quebec" Climate



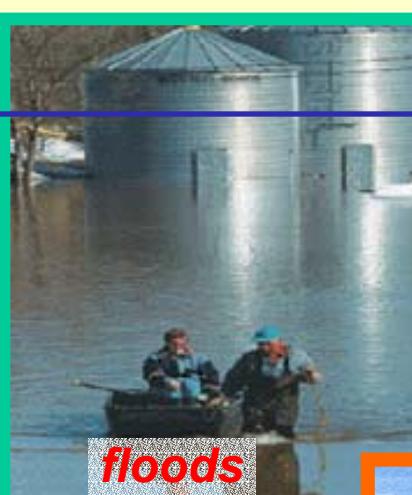
**large tides and storms**



**Saguenay (1996),  
26 millions m<sup>3</sup> of water  
and 9 millions tons of debris**



**The Great Ice Storm (1998), 1.5 millions  
customers without electricity for up to 30 days**



**floods**



**forest fires**



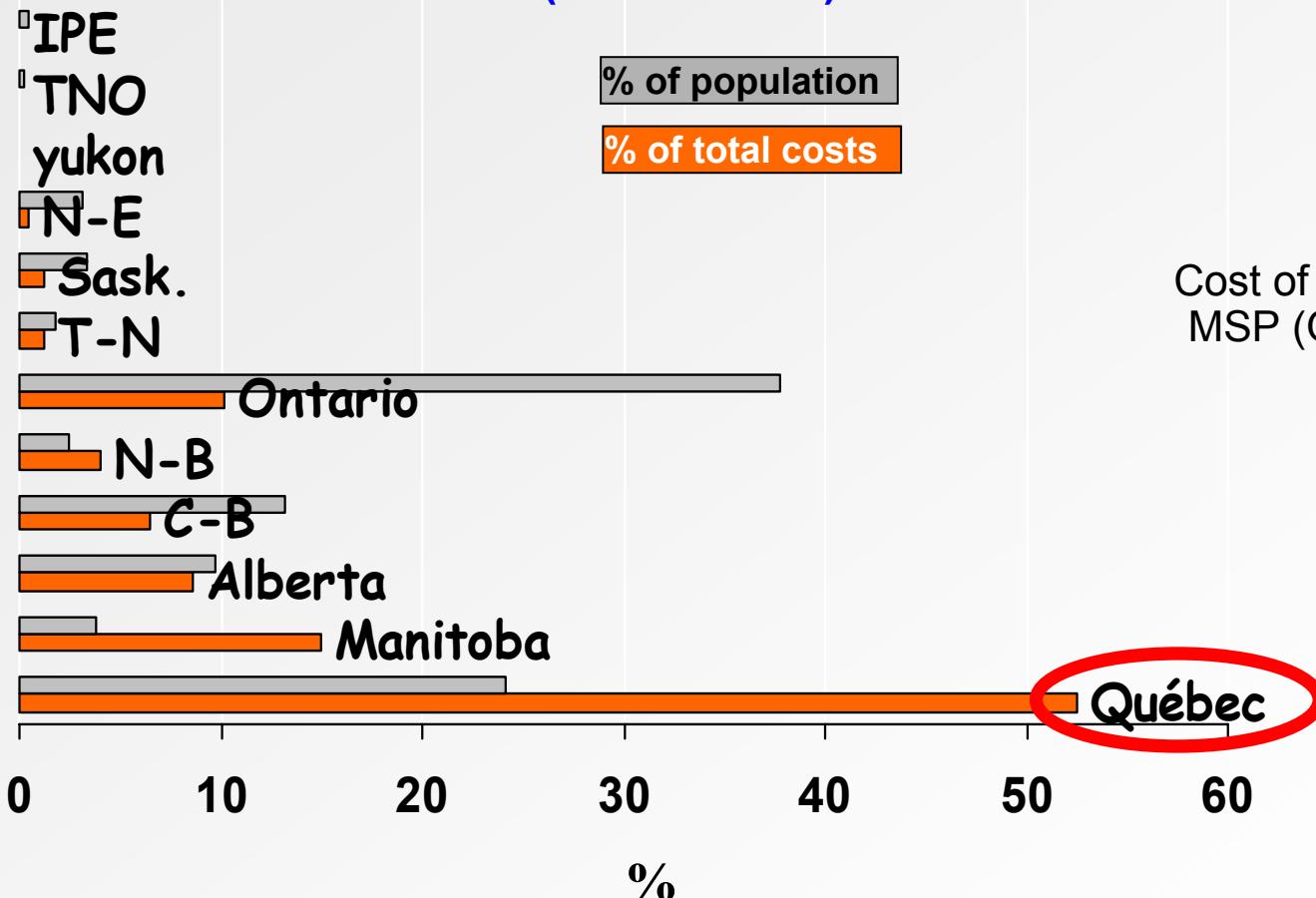
**droughts, heat spells**



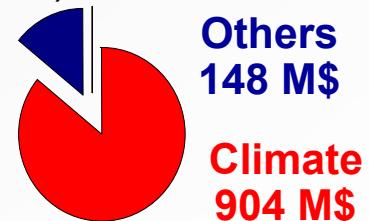
# *Increasing Costs of Extreme Weather ?*



## Costs of disasters (federal transfer) compared to populations (1970 – 1999)



Cost of disasters paid for by  
MSP (Québec) since 1982



# Québec Priorities in Adaptation



## Arctic:

- **Permafrost**

(infrastructures,  
housing,  
livelihood)

## Considerations :

- Economy
- Population:  
health and safety
- Environment and  
conservation
- System dynamics

- Reference scenarios on climate  
and socio-economics  
(for all sub-regions)

## Resources:

(sustainable development)

- **Hydroelectricity**
- **Forestry**

## St-Lawrence Valley:

- **Urban environment**
- **Rural environment**

## Social and Environmental Issues:

- Health in urban environment
- Impacts of extremes
- Drinking water supply
- Ecosystems and biodiversity

## Maritimes:

- **Coastal Erosion**
- Fisheries

## Economic Issues:

- Conflicts between users for the  
water in the St-Lawrence
- Water management
- Agriculture, agri-food,
- Transportation
- Energy demand profile
- Tourism

# La programmation d'Ouranos en 2004



## La science du climat

### Données historiques

- archives, validation, accès
- données dérivées

### Modélisation climat: recherche

- modèle régional
- couplage Baie d'Hudson

### Simulations climat

- développement
- production, analyse

Temps violent, Variabilité naturelle

Analyses statistiques

scénarios climatiques, socio-économiques

### Analyse du climat

- Scénarios climat
- Mise à l'échelle statistique
- Analyse statistique
- Temps violent
- Régime de temps

## Les 10 grands programmes à Ouranos

## Impacts et stratégies d'Adaptation par régions

### Nordique

- Pergélisol et transport
- Pergélisol et communauté
- Accessibilité du territoire

### Forêts

- Production
- Feux
- Dommages par extrêmes

### St-Laurent fluvial

- Évaluation niveaux d'eau
- Outaouais
- Sédiments tributaires
- Impacts: biophysique, économique
- Stratégies d'adaptation

### Hydroélectricité

- Tourbières
- Variabilité naturelle
- Hydraulicité
- Utilisation des simulations climat

### Maritimes

- Érosion côtières sur 3 zones témoins

### Sud du Québec

- Eau : potable, drainage urbain, design-fortes pluies
- Bassin Châteauguay: nappe phréatique, crues, ...
- Agroalimentaire: économique, impacts des extrêmes
- Santé: allergies-canicules, santé urbaine
- Tourisme ski-golf

## Information pour les décideurs

Intégration des connaissances

Evaluation des impacts

Stratégies d'adaptation, opportunités économiques

Québec

Hydro Québec

Environnement Canada Environment Canada

UQÀM  
Université du Québec à Montréal

McGill

UNIVERSITÉ  
LAVAL

Université du Québec  
Institut national de la recherche scientifique

# **Canada's Ouranos: Consortium on regional climate and adaptation to climate changes**

<http://www.ouranos.ca/>

- Created May 2002 by:
  - Government of the Province of Québec
  - Hydro-Québec (hydro-electric power utility)
  - Meteorological Service of Canada
  - Participating Québec Universities

**MISSION:** “Advance the understanding of the issues and the associated requirements for adaptation resulting from climate change on the scale of the North American continent”

# **Ouranos:**

## **Consortium on regional climate and adaptation to climate changes**

<http://www.ouranos.ca/>

- Mission of Ouranos:
  - To generate “regional” scenarios for the evolution of the climate and its expected impacts, and to make them available to the decision-maker partners of Ouranos.
  - To develop expertise and strategies so as to mitigate the impact of climate change and to capitalize on potential economic benefits

# Ouranos

<http://www.ouranos.ca/>

- To promote the acquisition of expertise that will advance the understanding of regional climate change and of its environmental, social, and economic impacts
- To develop and adapt the tools necessary for providing decision makers with detailed climate change scenarios on a regional scale
- To performs evaluations of expected sectorial impacts in order to optimize adaptation strategies.

# Ouranos

<http://www.ouranos.ca/>

- Participates in the construction of historical climate databases
- Supports the development of the Canadian Regional Climate Model (CRCM)
- Runs climate simulations on the geographic scales required for various impact and adaptation studies
- Analyses various phenomena connected to statistical variability
- Develop detailed medium and long term scenarios of the evolution of the Québec climate
- Determine the principal vulnerabilities of different regions and sectors in Québec, in terms of the physical environment and of the impact on humans and the economy
- Helps to establish priority areas of intervention and develop adaptation strategies to mitigate the impacts or to capitalize on economic opportunities

# Réseau canadien de Modélisation Régionale du Climat (Réseau MRCC)

**Canadian Network for  
Regional Climate Modelling  
(CRCM Network)**

René Laprise  
Principal Investigator

Professeur, Université du Québec à Montréal (UQÀM)

27 octobre 2003

# Co-Is of CRCM Network

## UQÀM:

Blanchet Jean-Pierre  
Girard Éric  
Laprise René  
Larocque Marie

Aerosols, Radiation, Arctic climate  
Arctic and Clouds microphysics  
Num. methods, climate modelling  
Hydrological processes

## Ouranos:

Caya Daniel  
Slivitzky Michel

Regional climate modelling  
Hydrology and climate variability

## IML/DFO - UQÀR Rimouski:

Saucier François

Regional Ocean Modelling

## CCCma/MSC Victoria:

Boer George  
McFarlane Norman  
Zwiers Francis

Climate Diagnostic, O-A coupling  
Physical param. in climate models  
Climate and Statistical Analysis

## RPN/MSC Dorval:

Brunet Gilbert  
Côté Jean

Weather prediction, diagnostics  
Variable Resolution modelling

# **CRCM Network**

# **Scientific Research Plan**

# **2003 - 2006**

## **3 main themes:**

1. Diagnostics and budget studies
2. Dynamical downscaling approaches
3. Development of the CRCM system

# 1. Diagnostics and budget studies

## 1.1 Scale-selective diagnostic budget studies

Laprise, Boer and Caya

PDF Soline Bielli

PhD Leticia Hernández-Díaz

## 1.2 A Decadal-scale Canadian experiment

Caya and Laprise

PDF Yanjun Jiao

PhD Biljana Music

## 1.3 Regional-Scale Seasonal Prediction Project (with GEM-VR)

Brunet, Laprise, Caya and Zwiers

PhD Hatem Yazidi

## 1.4 Atmospheric Models Intercomparison Project (AMIP-II, SGMIP) (with GEM-VR)

Côté, Laprise and Caya

RA Katja Winger

1 Graduate Student

## 1.5 Arctic Model Intercomparison Project (ARCMIP, GLIMPSE)

Girard, Blanchet, McFarlane, Laprise and Caya

RA Rong-Ming Hu

MSc Biljana Bekcic

## 1.6 Project to Intercompare Regional Climate Simulations (PIRCS 1c & 2)

Caya, Laprise and Côté

MSc Bertin Ossonon

## **2. Dynamical downscaling approaches**

### **2.1 Big-Brother Experiment**

Laprise and Caya

PhD Milena Dimitrijevic

### **2.2 Influence of surface forcing and large-scale nudging on RCM internal variability**

Caya and Laprise

PhD Philippe Lucas-Picher

### **2.3 Internal variability of RCM in ensemble simulations**

Laprise and Caya

PDF Ramón de Elía

### 3. Development and improvements in the CRCM

#### 3.1 Regional Ocean Coupling

Saucier, Caya, Laprise and Boer

1/3 RA Simon Senneville

PDF Minwei Qian

2 Graduate Students

#### 3.2 River-routing and surface water processes

Caya, Slivitzky, Larocque, Laprise and Saucier

PDF Laxmi Sushama

1 Graduate Student

#### 3.3 Physical parameterisation including land-surface processes ([CRCM\\_4](#))

Laprise, Caya and McFarlane

RA Arturo Quintanar

1 Graduate Student

#### 3.4 Computer code parallelisation ([CRCM\\_5](#))

Laprise, Côté, Zwiers and Caya

1 Research Assistant

1 Graduate Student

# ***Simulations climatiques régionales à Ouranos***

**Daniel Caya**

*Directeur, Simulations climatiques*

1<sup>er</sup> Symposium Ouranos  
Montréal, 9 et 10 juin 2004

- Programme Simulations climatiques
- Activités 2003 - 2004
  - Simulations complétées
- Programme d'activités 2004 - 2006



*Consortium sur la climatologie régionale et l'adaptation aux changements climatiques*

# Mandate for the team

## *Simulations climatiques*

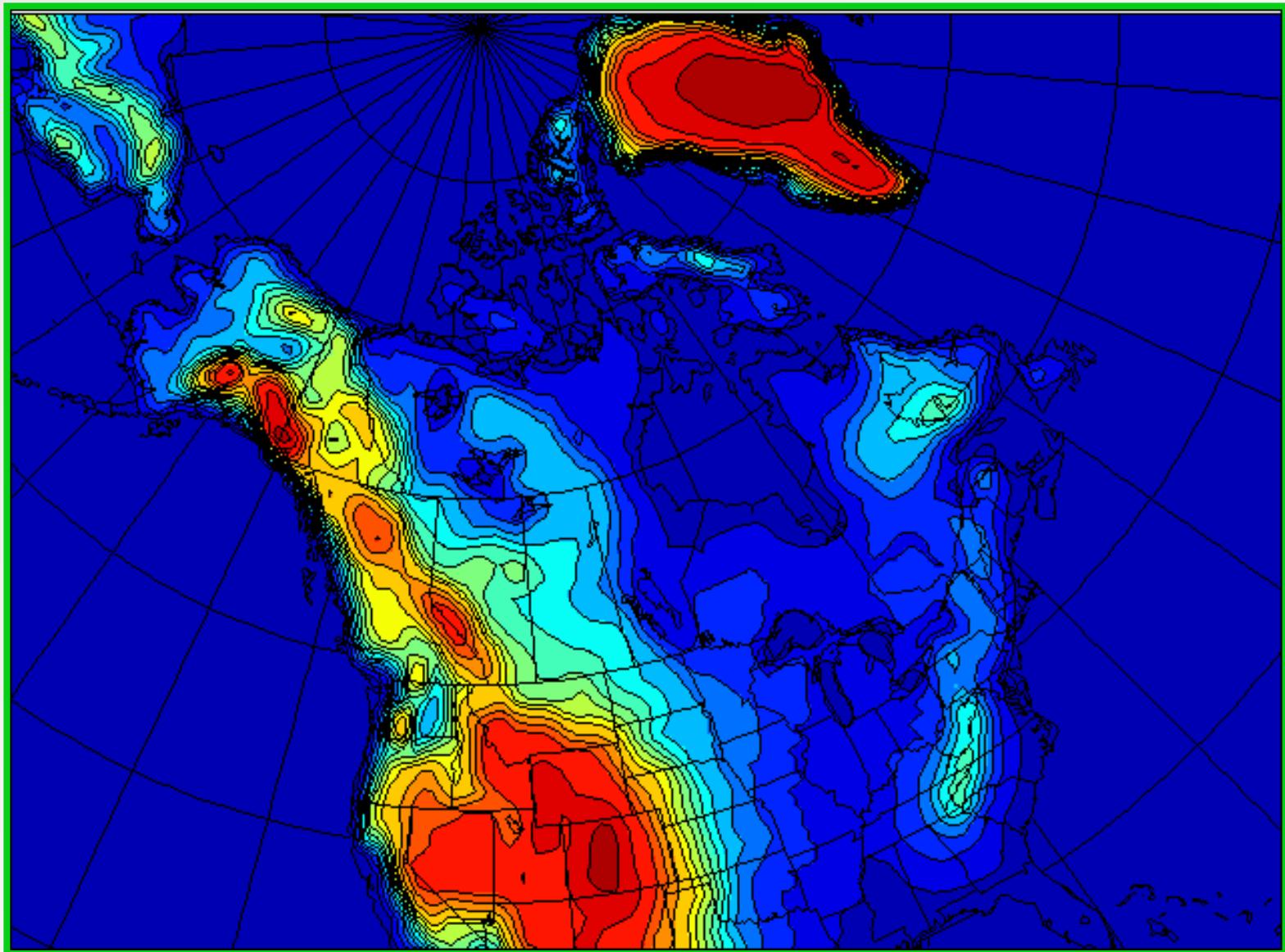
- Supply Ouranos' partners with reliable regional climate projections
- Evaluation of the uncertainties associated to the projections
- Help impacts and adaptation scientists in the use of the projections

# Équipe Simulations

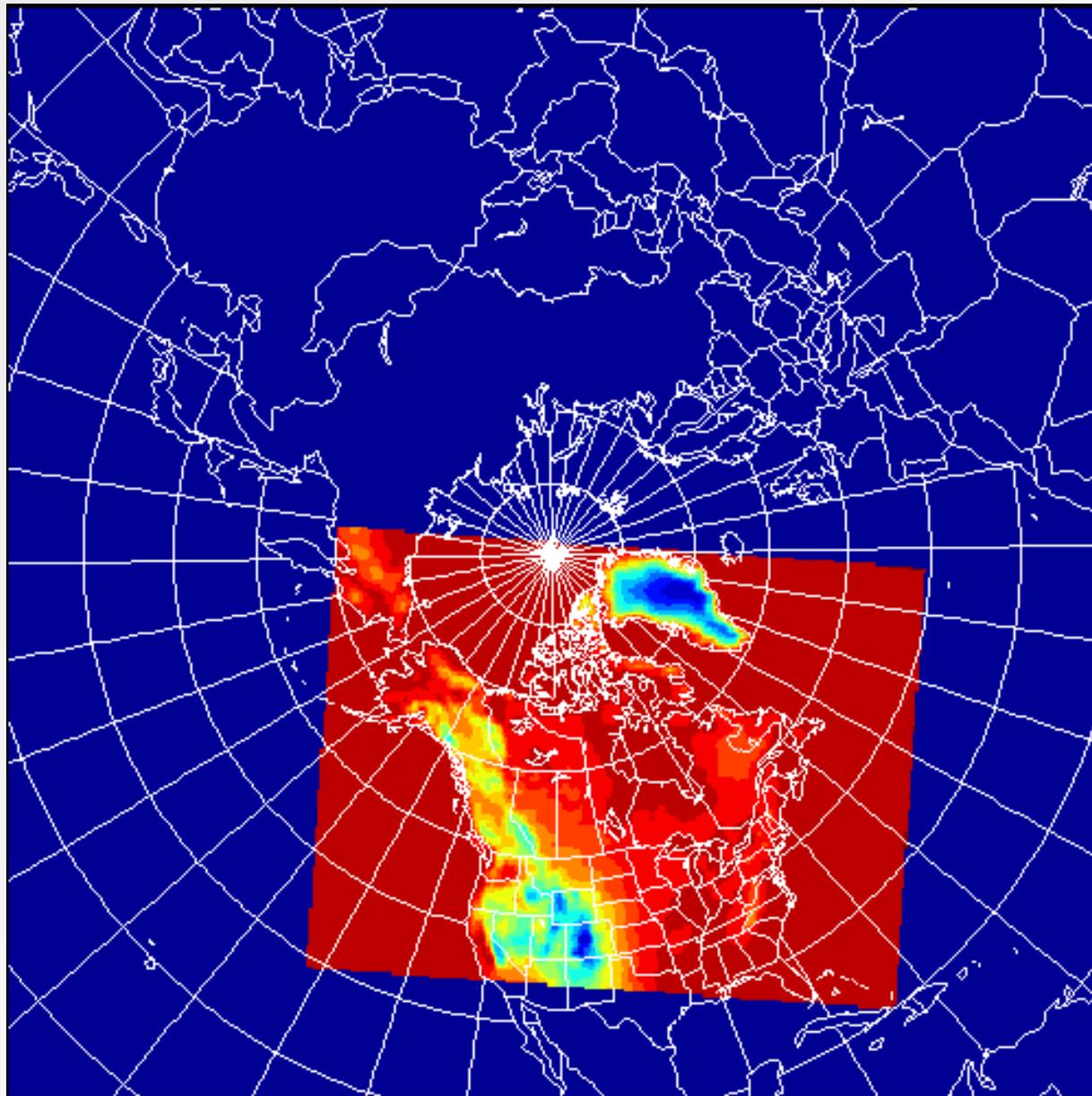
## Objectives for year 1 (2003)

- Make an operational environment for CRCM
- Define an integration domain compatible with Ouranos needs
- Generate the first climate projections over Québec and Canada
- Evaluation of the simulations

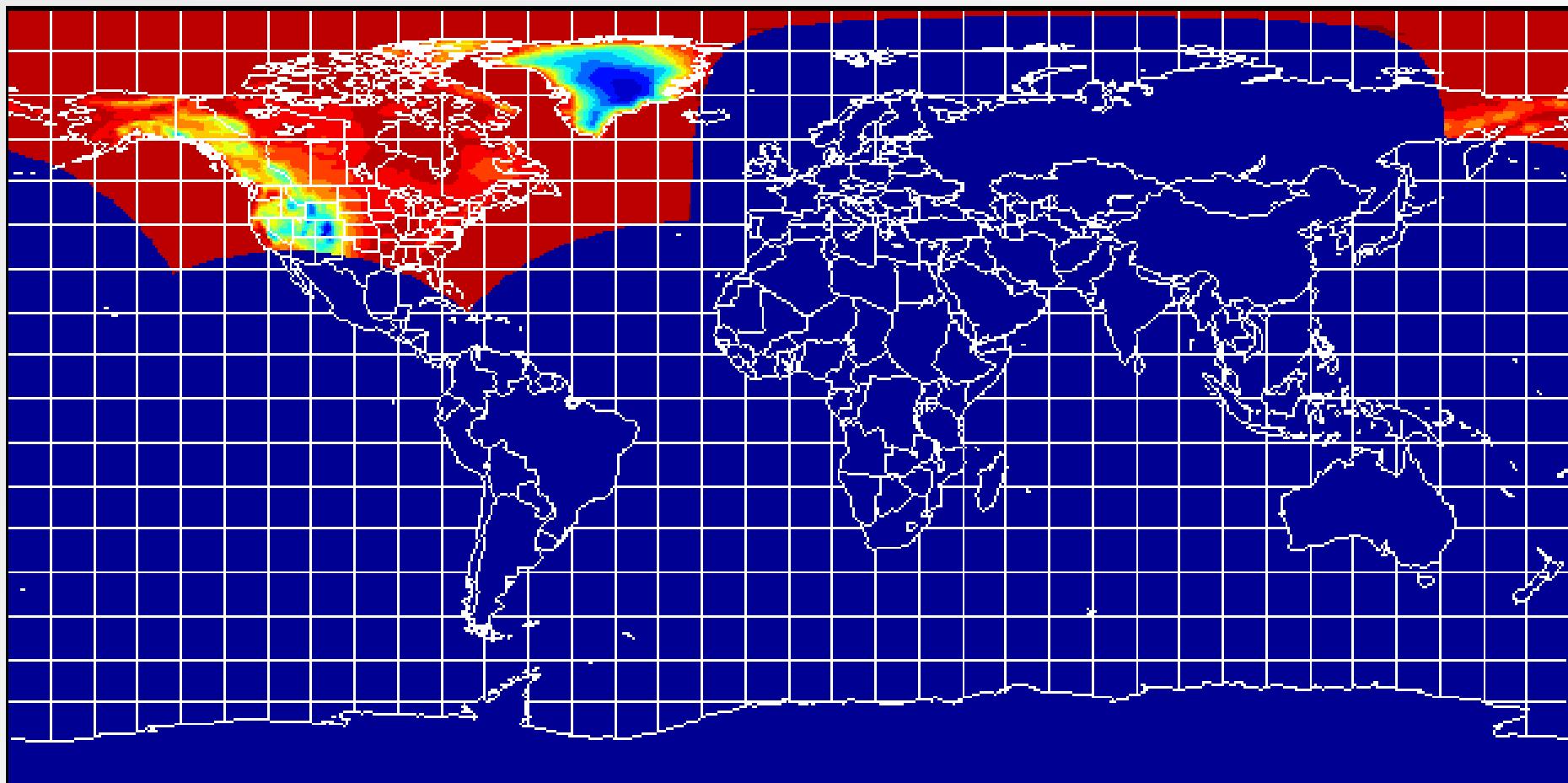
# Le domaine MRCC pour Ouranos



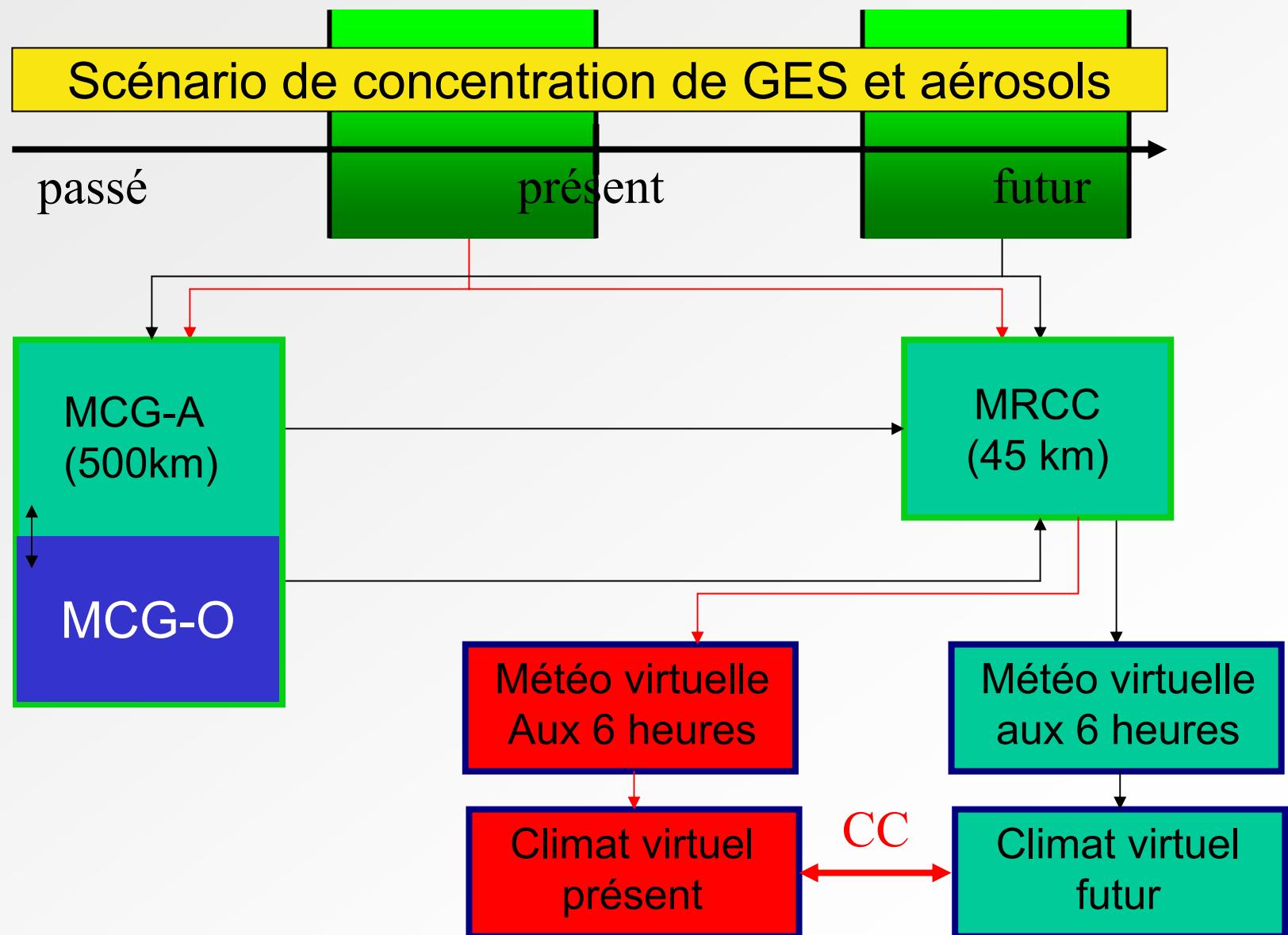
# Le domaine PCAN

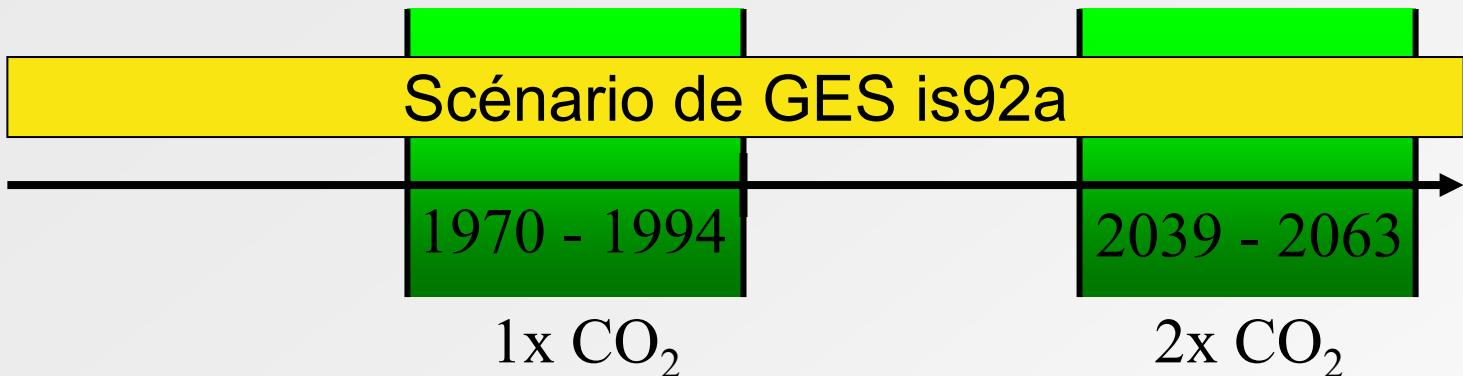


# Le domaine PCAN



# Système de modélisation régionale du climat



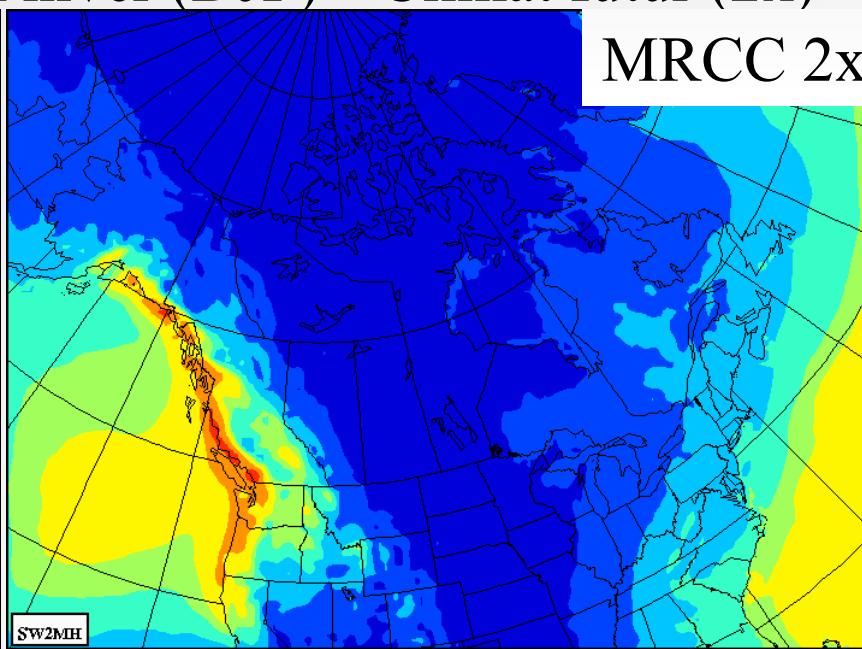
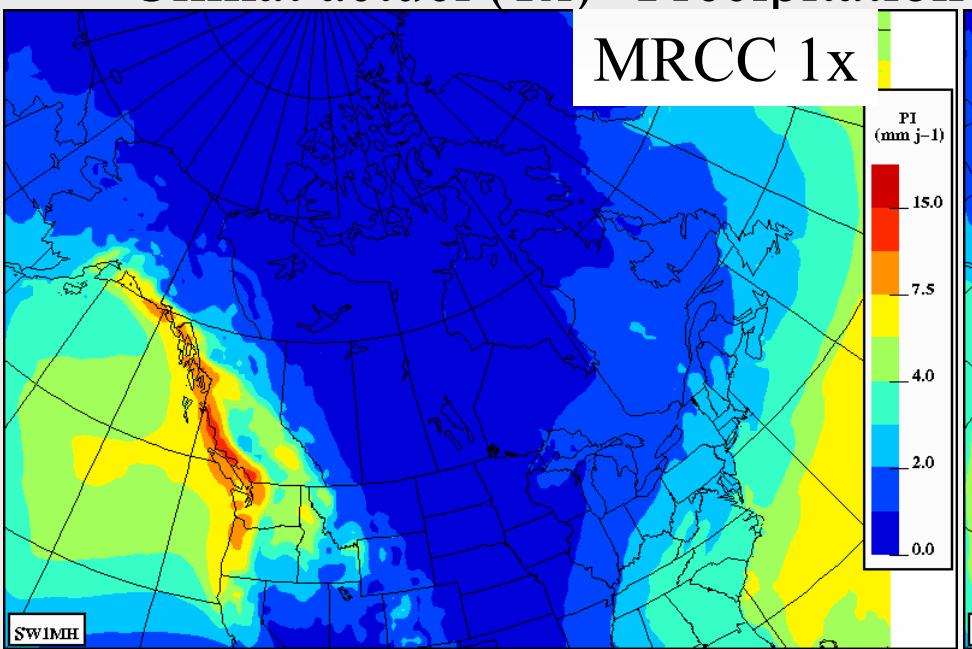


## Résultats - Projection climatique précipitation, température, neige au sol

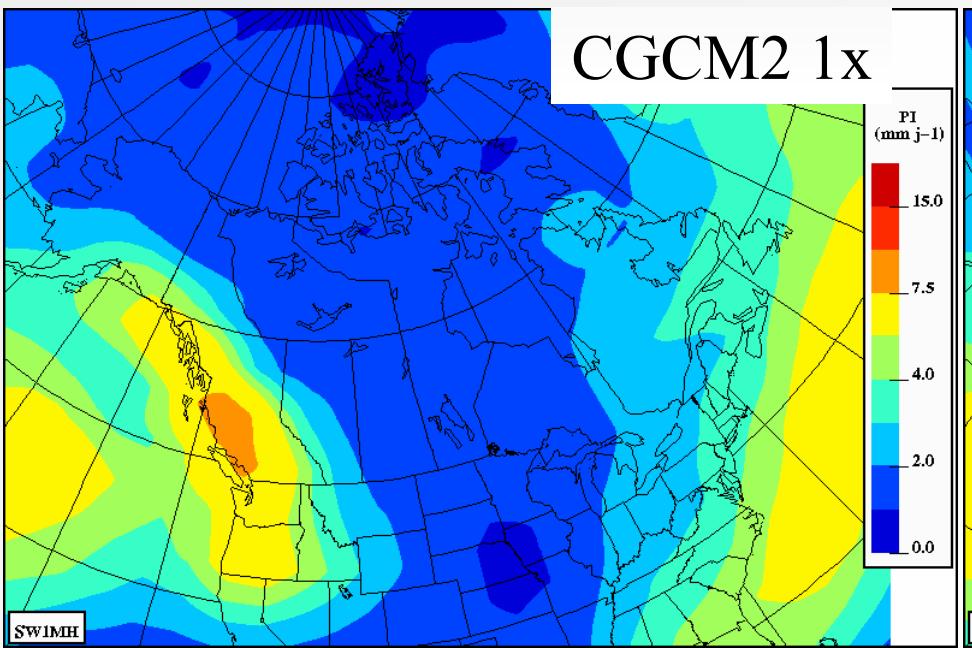
MRCC piloté par CGCM2 (is92a)  
CGCM2 is92a

Climat actuel (1x) Précipitation hiver (DJF) Climat futur (2x)

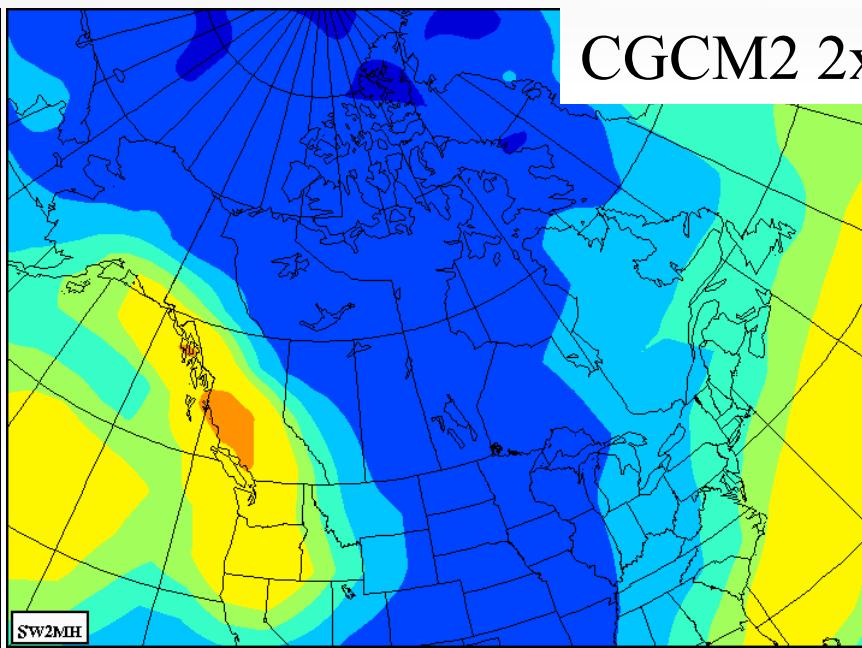
MRCC 1x



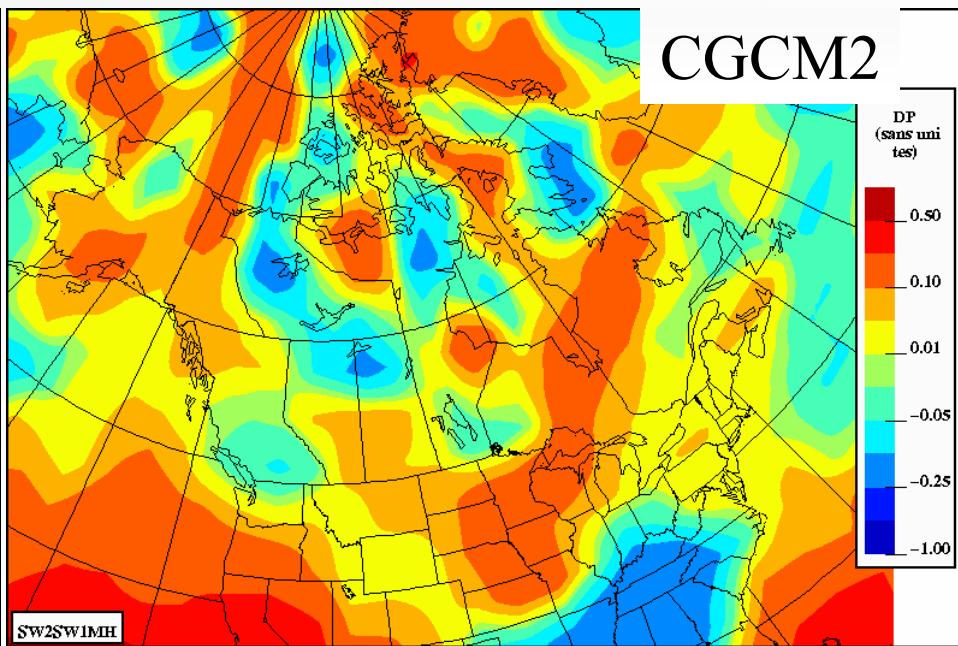
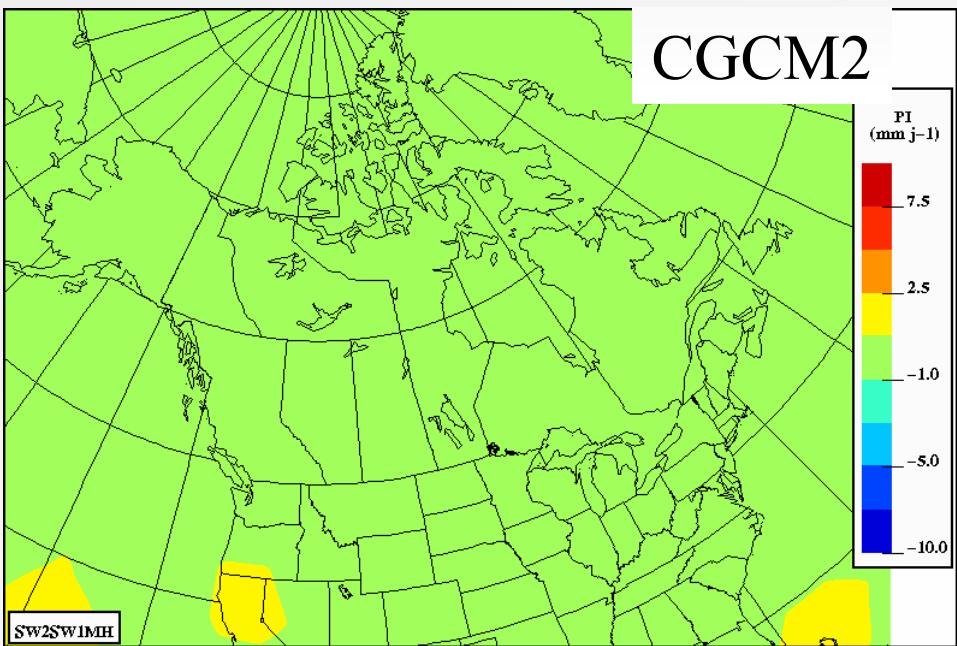
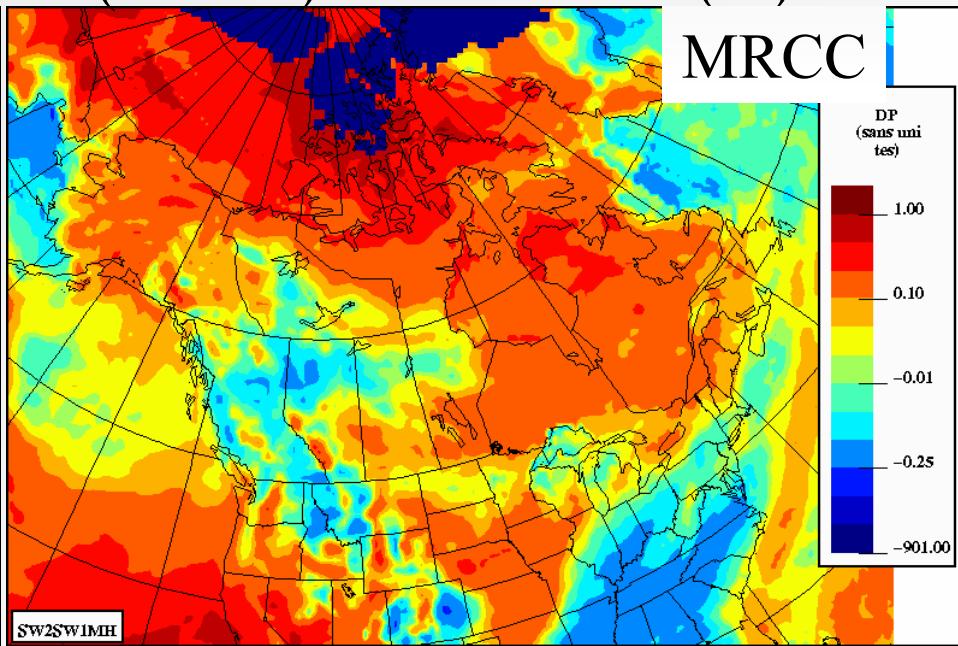
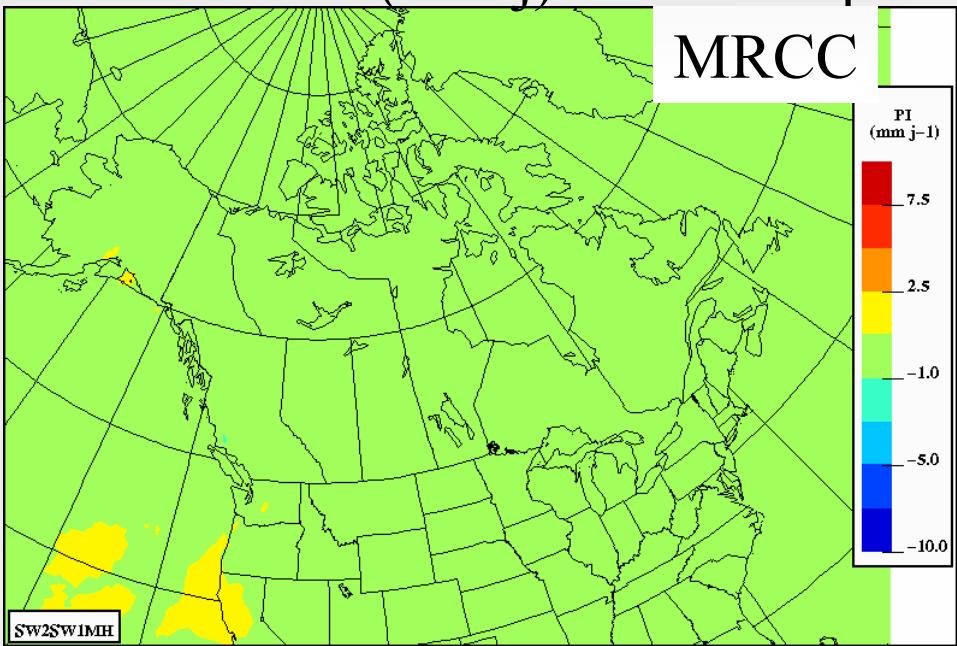
CGCM2 1x



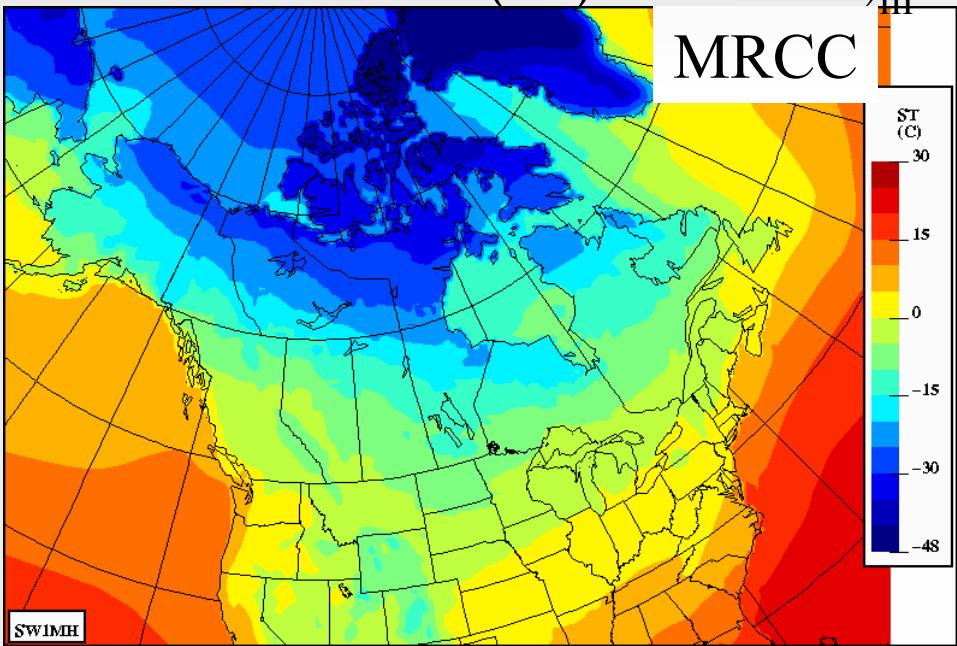
CGCM2 2x



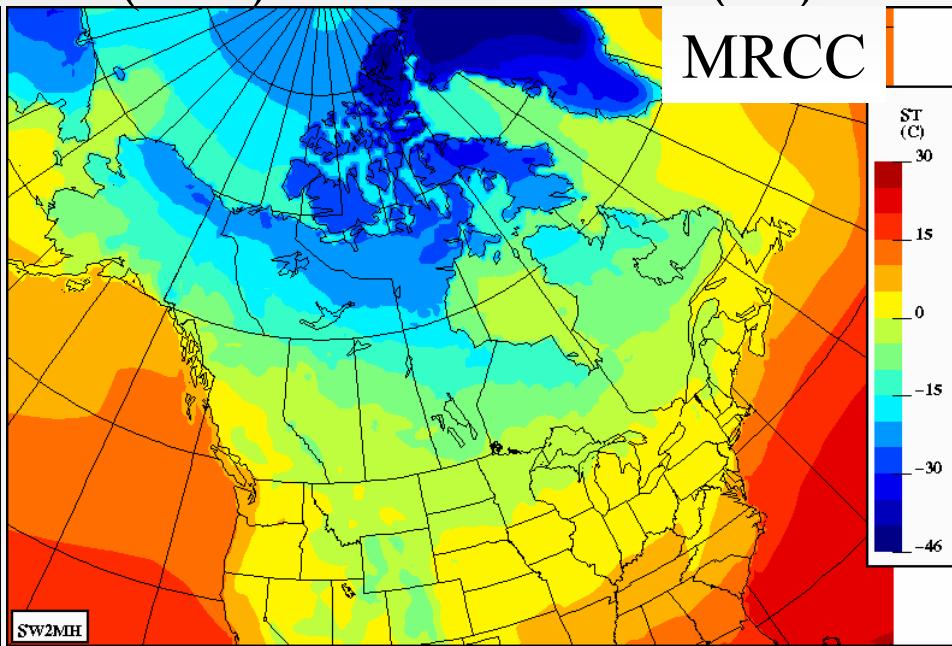
# Absolu (mm/j) Delta Précipitation (2x - 1x) DJF Relatif (%)



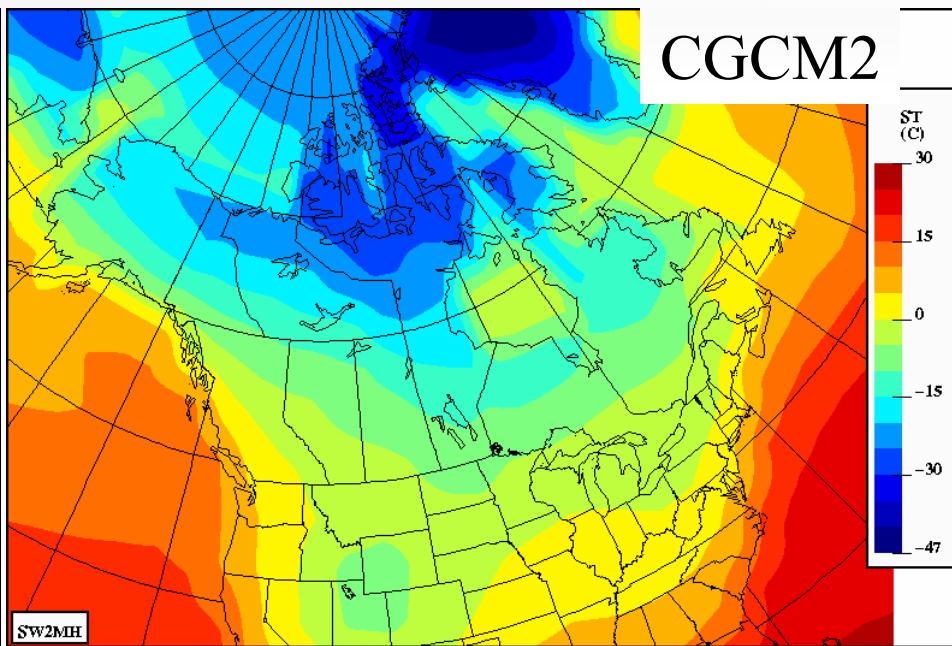
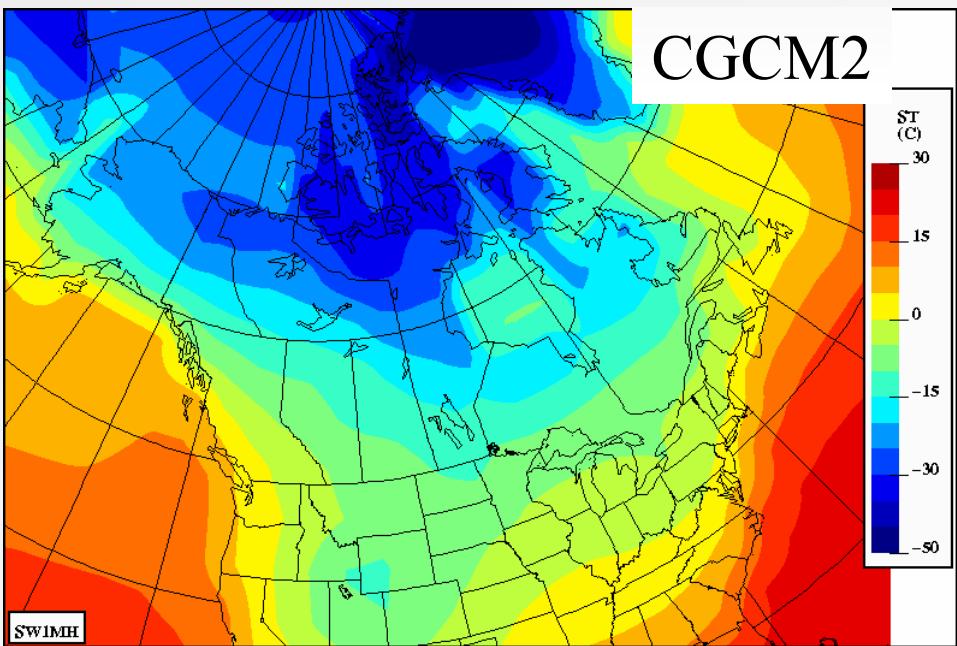
Climat actuel (1x)



TEMP<sub>2m</sub> hiver (DJF)



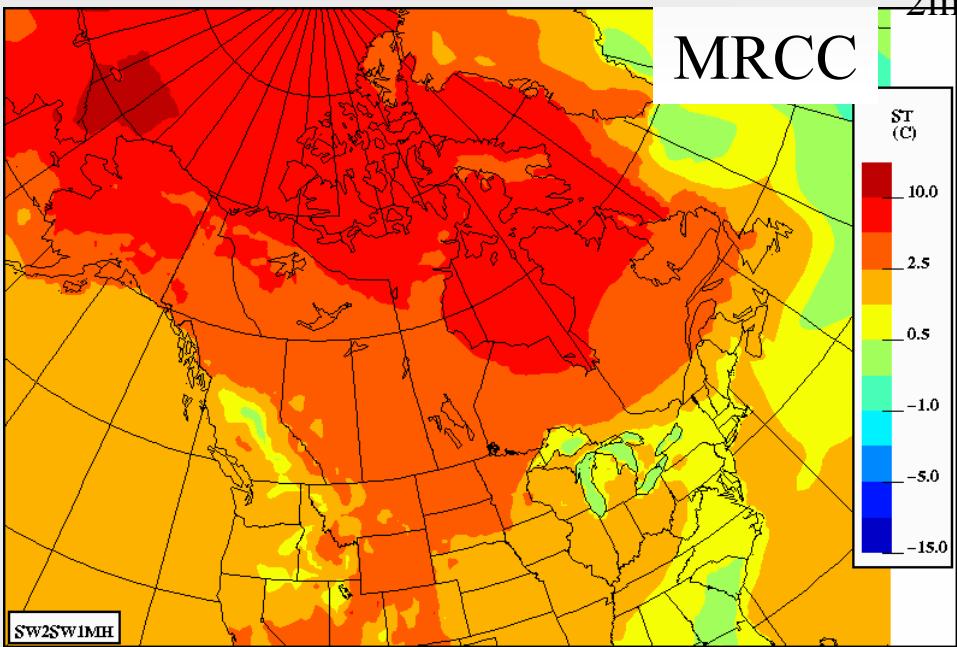
CGCM2



DJF

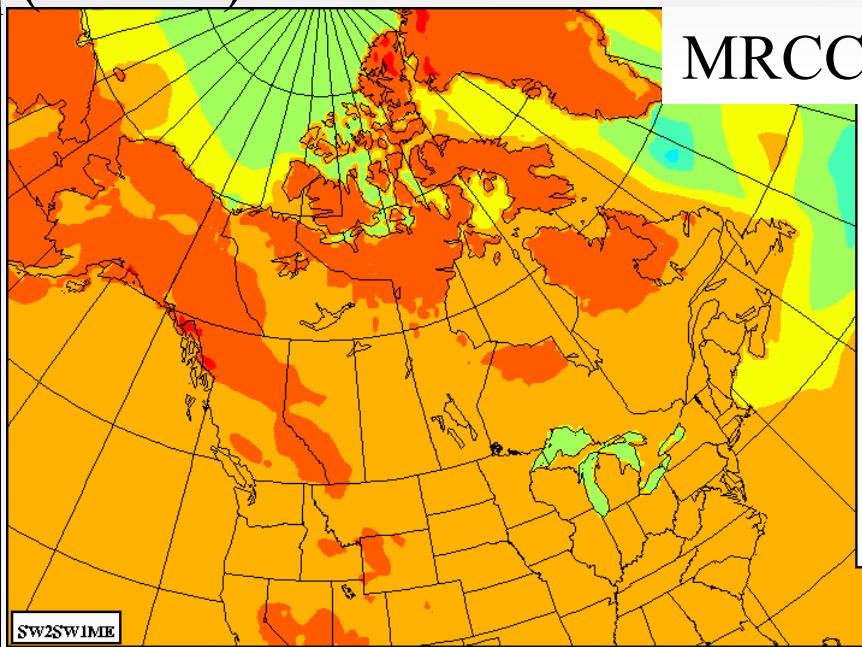
Delta  $T_{2m}$  ( $2x - 1x$ )  
MRCC

JJA



SW2SW1MH

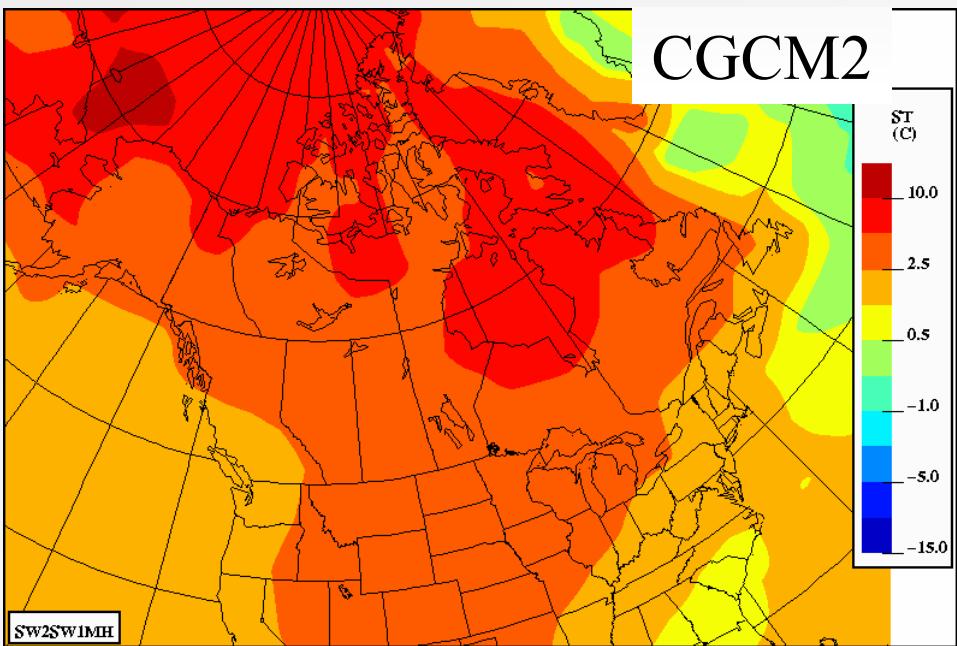
ST  
(C)  
10.0  
2.5  
0.5  
-1.0  
-2.5  
-5.0  
-15.0



SW2SW1ME

ST  
(C)  
10.0  
2.5  
0.5  
-1.0  
-2.5  
-5.0  
-15.0

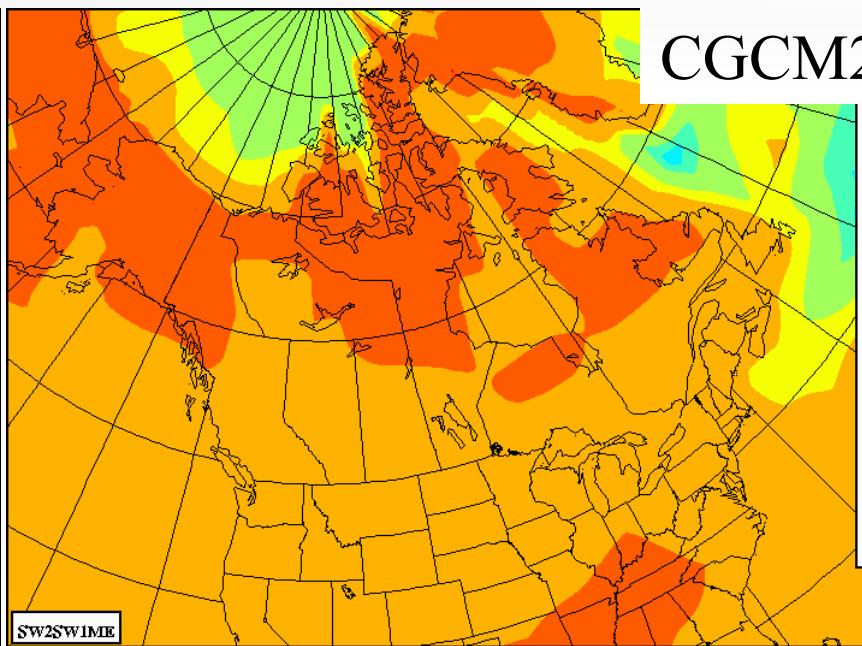
CGCM2



SW2SW1MH

ST  
(C)  
10.0  
2.5  
0.5  
-1.0  
-2.5  
-5.0  
-15.0

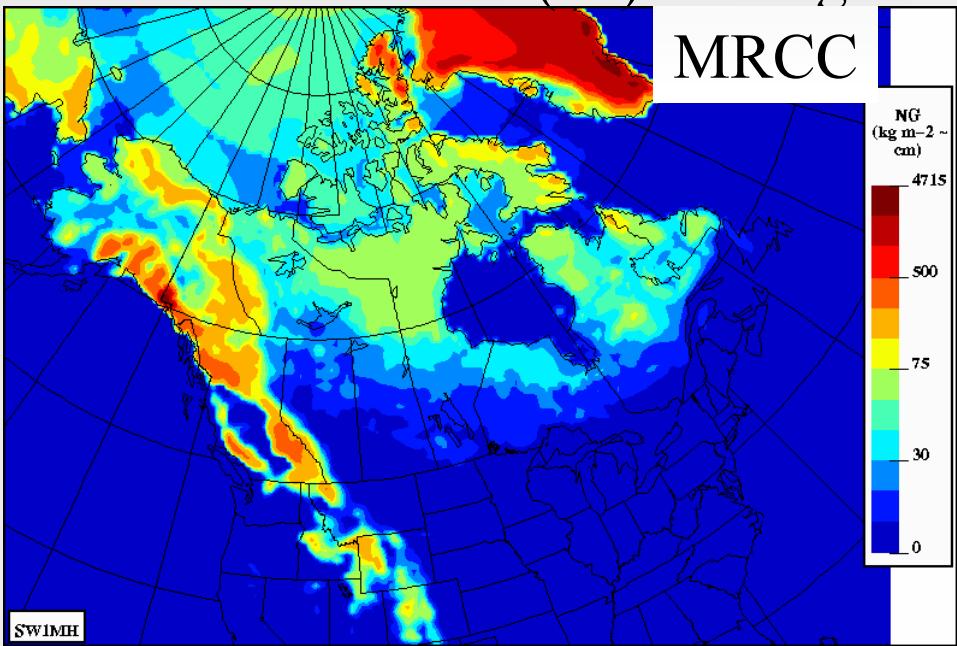
CGCM2



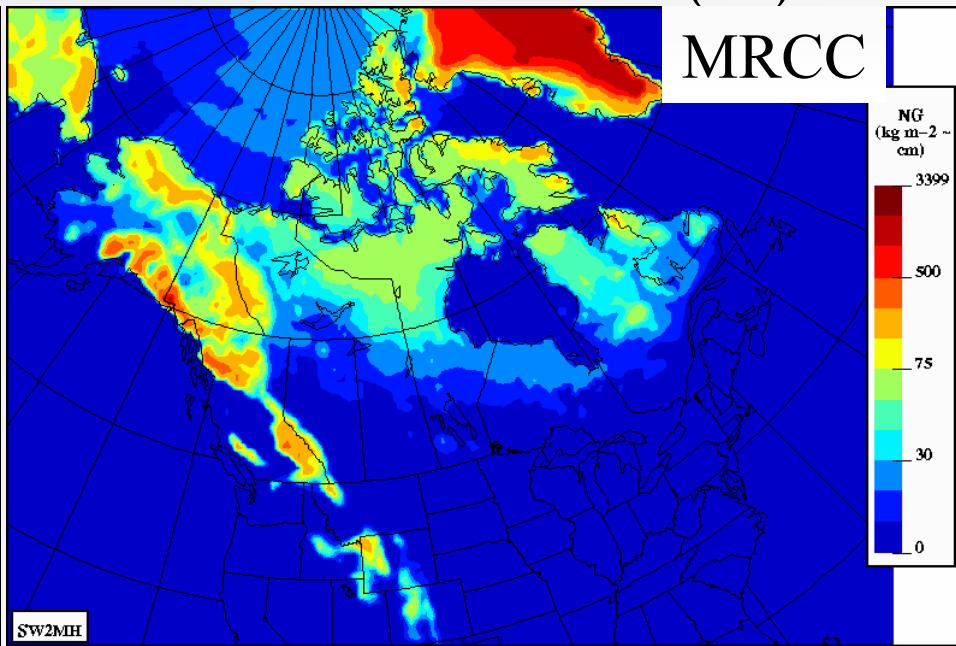
SW2SW1ME

ST  
(C)  
10.0  
2.5  
0.5  
-1.0  
-2.5  
-5.0  
-15.0

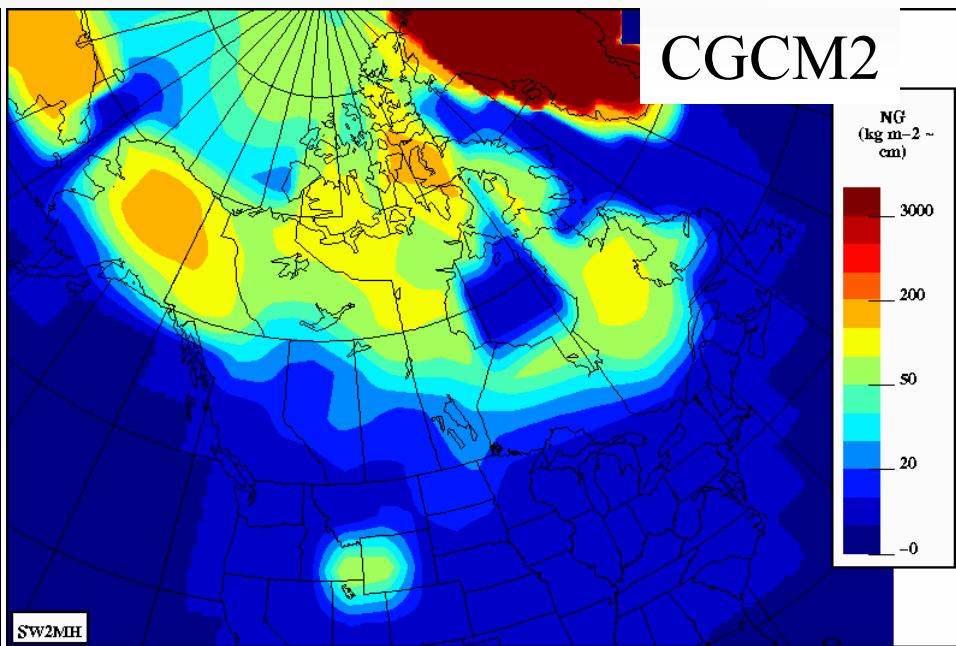
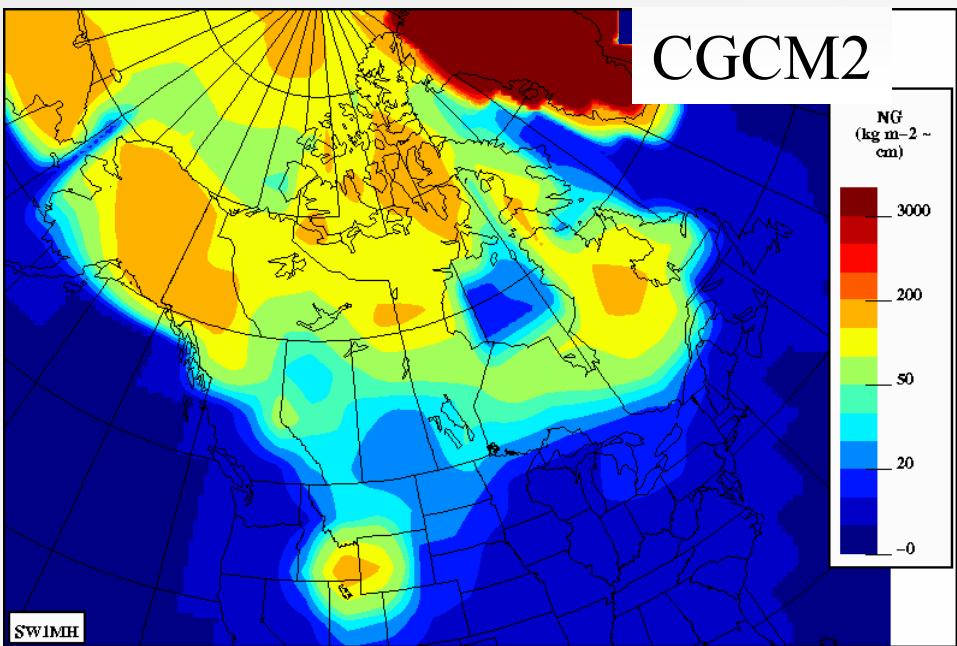
Climat actuel (1x)



Neige au sol hiver



Climat futur (2x)

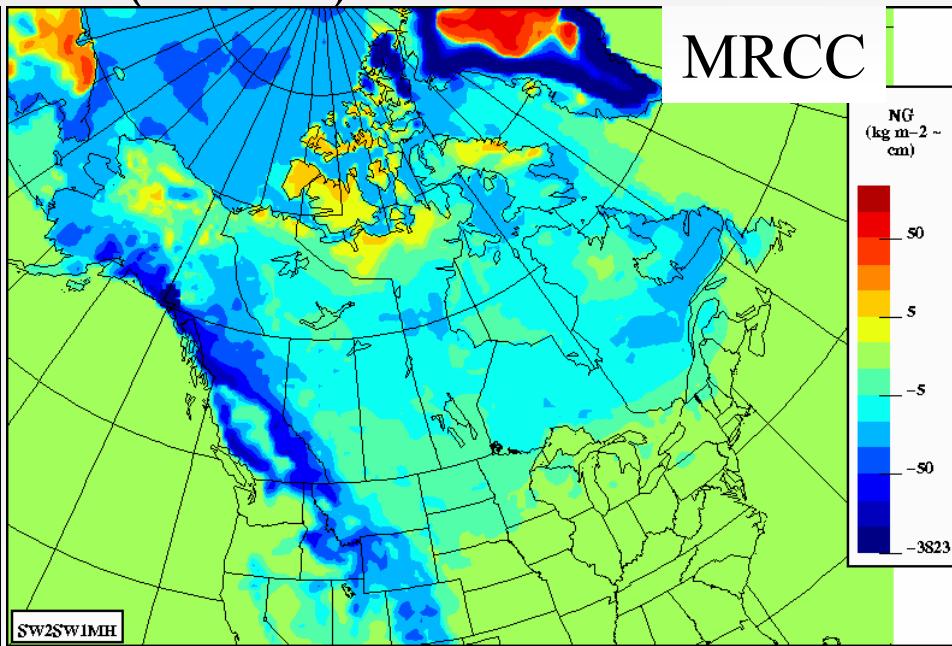
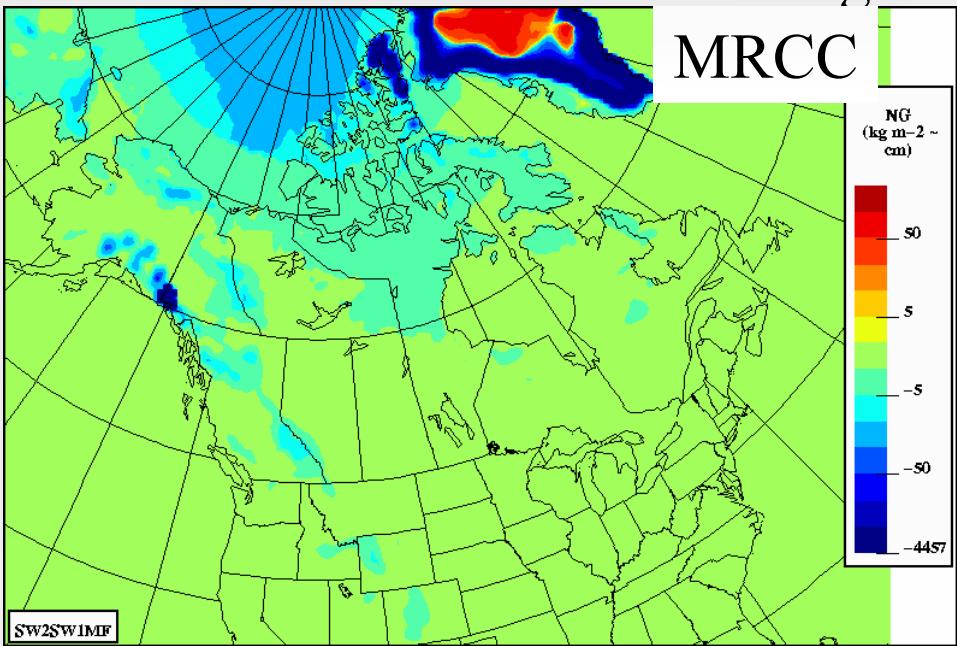


SON

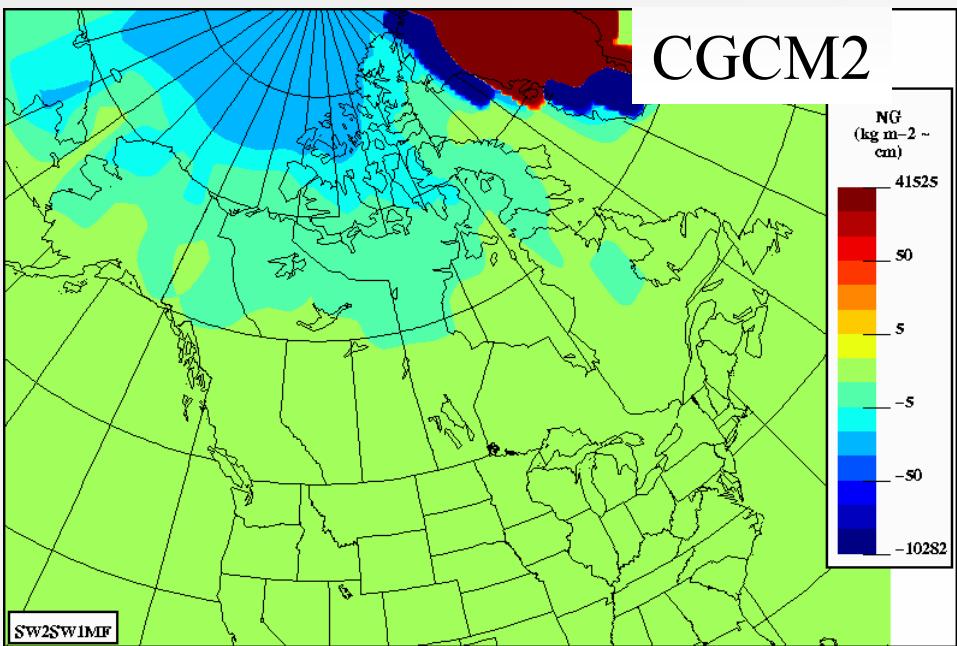
Delta neige au sol (2x - 1x)

DJF

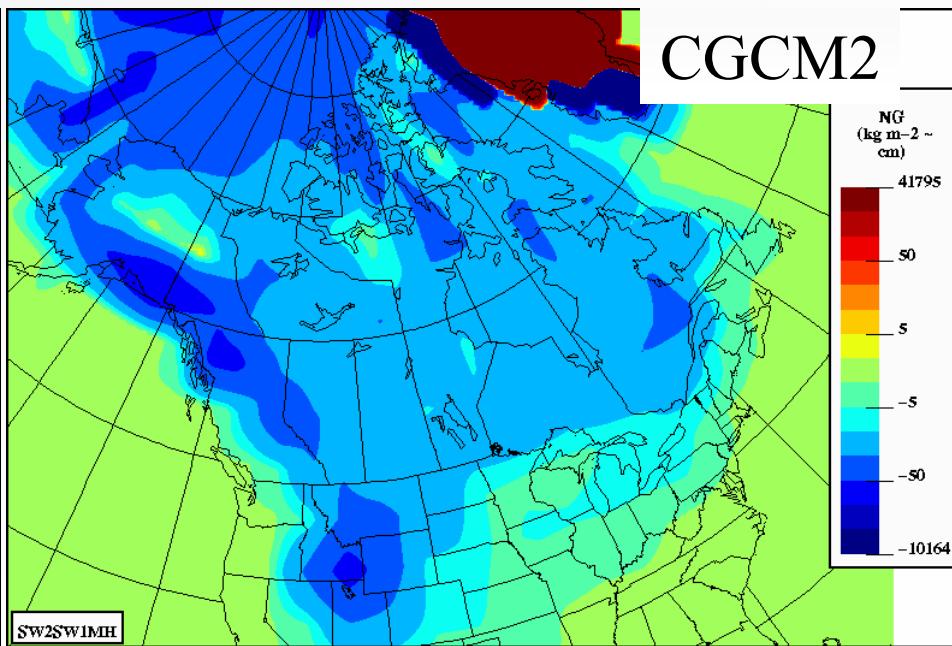
MRCC

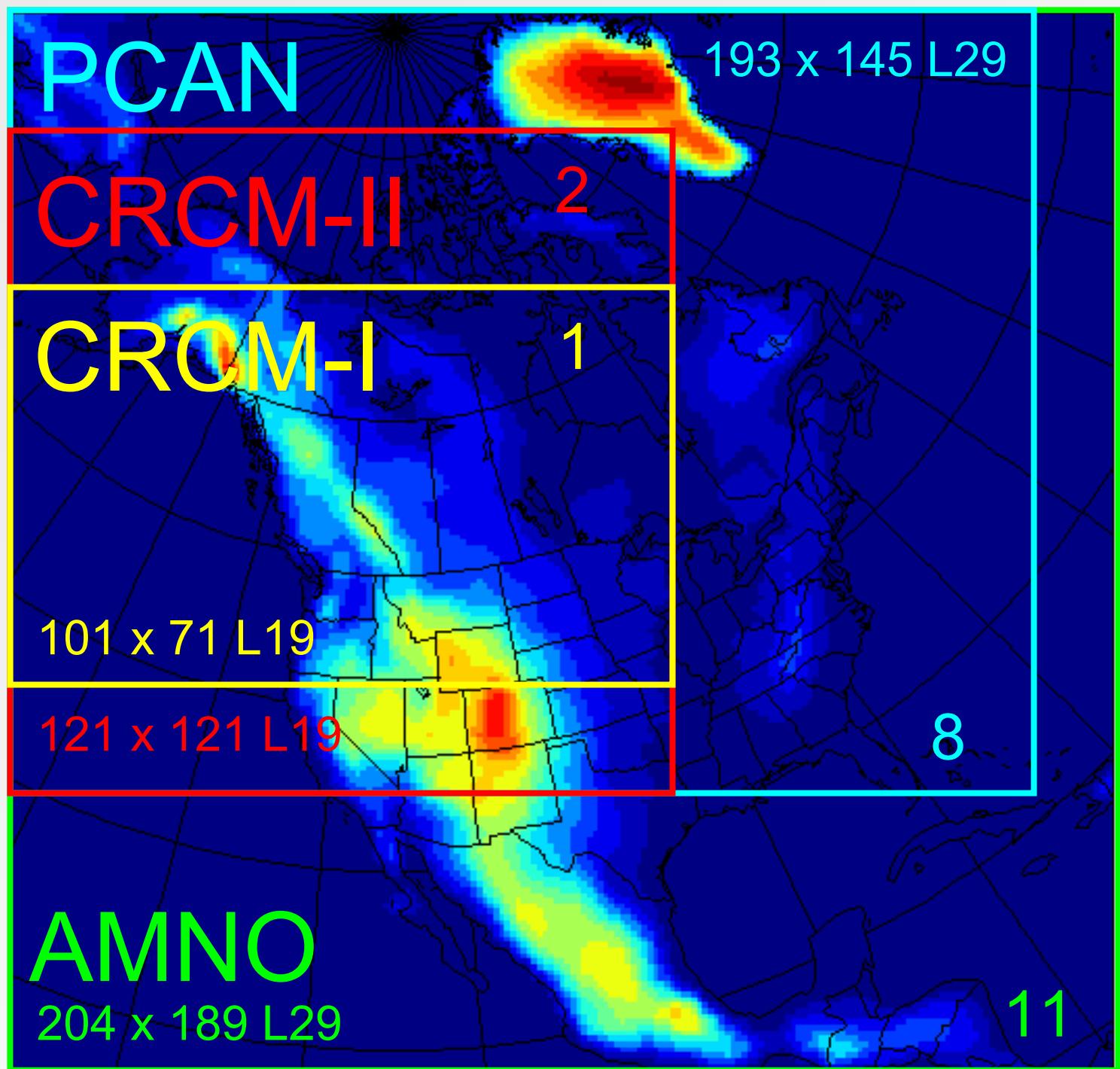


CGCM2



CGCM2



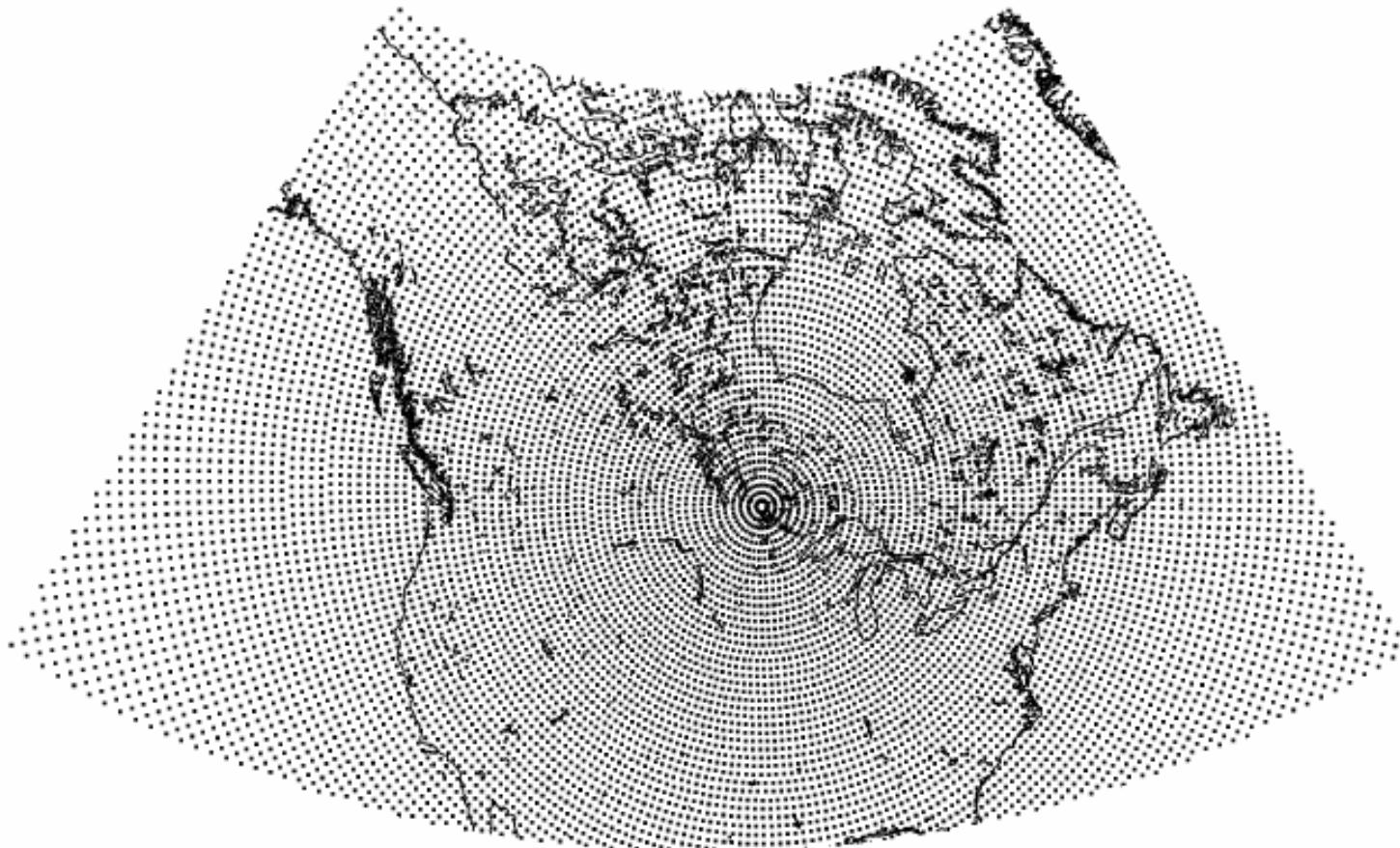


# Collaboration Ouranos - Météo-France

- Entente entre Québec et la France sur la modélisation climatique régionale
- Échange d'expertise et d'outils (modèles)
- Les modèles Arpège climat (mondial), Arpège étiré et Aladin seront installés sur les ordinateurs d'Ouranos
- Le MRCC sera utilisé sur un domaine européen permettant une comparaison avec la plupart des modèles régionaux et l'utilisation des immenses banques de données européennes disponibles pour la validation

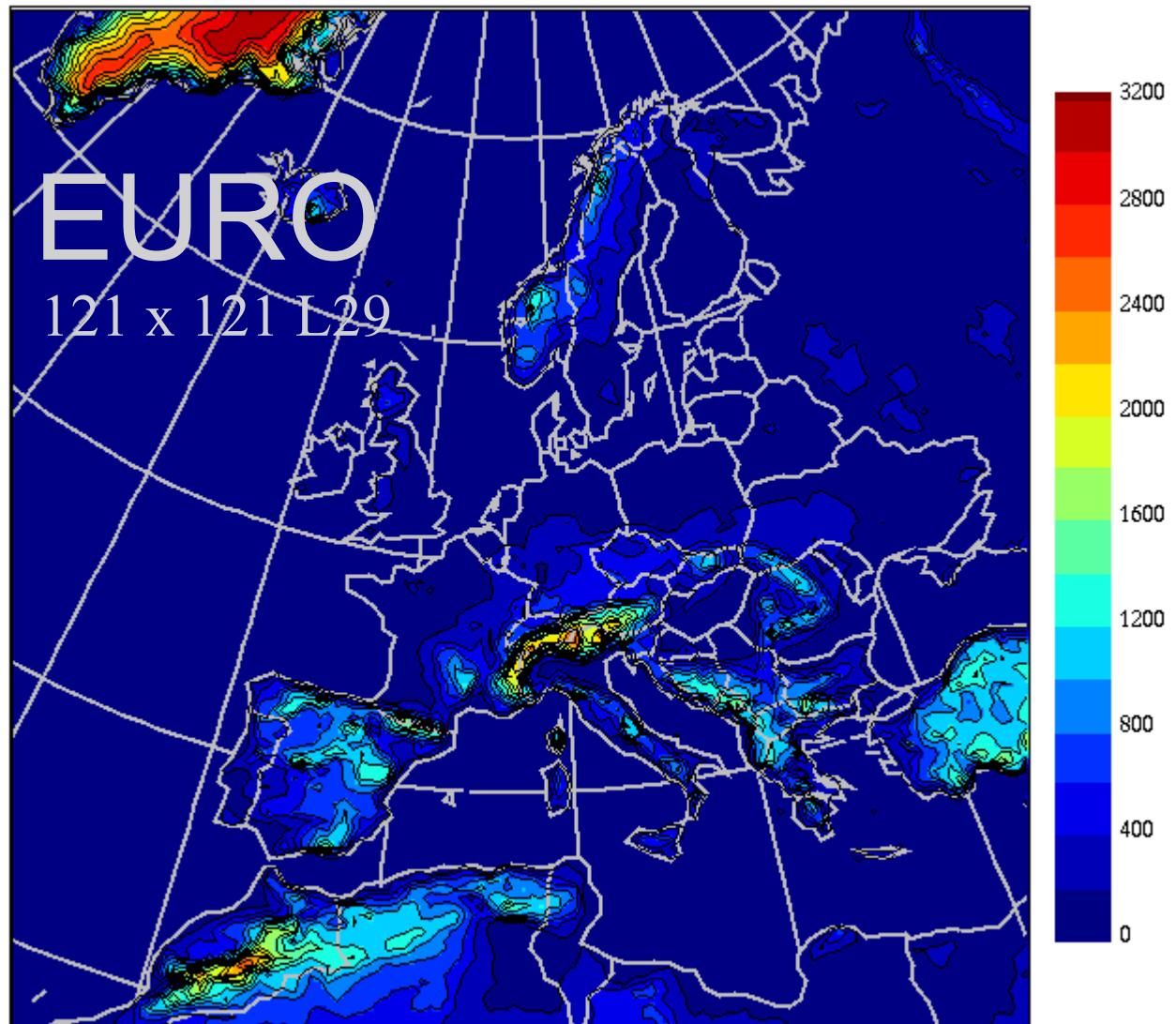
# Collaboration Météo-France

Arpège-étiré sur domaine pan-canadien



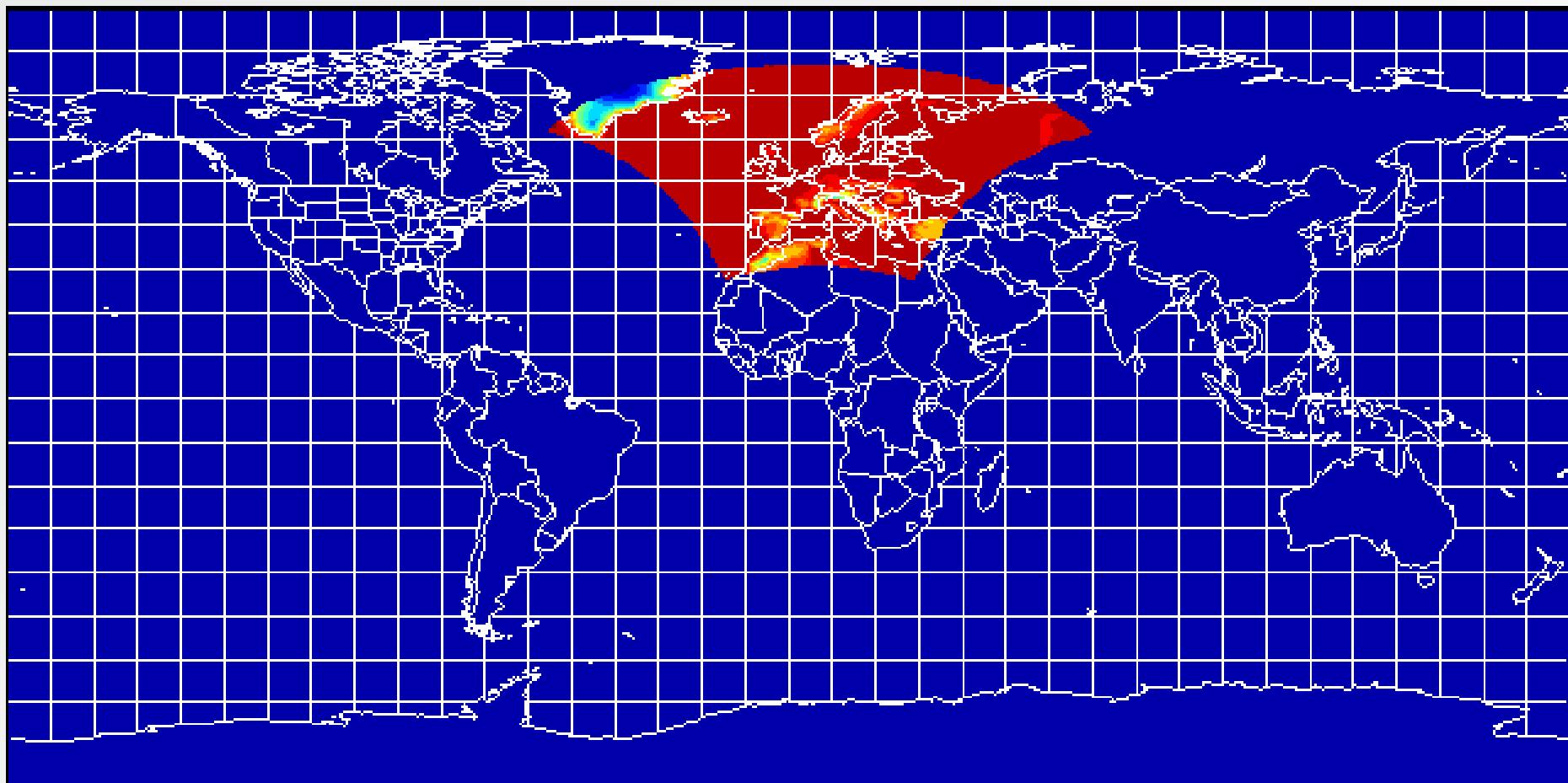
ZS (Topographie) PHIS

Niveau sigma: 1.000 - Etiquette: AVANT - Intervalle: 200 \* 1.0e+00 m



Prévision 00 heures valide 00:00Z le 01 janvier 1979

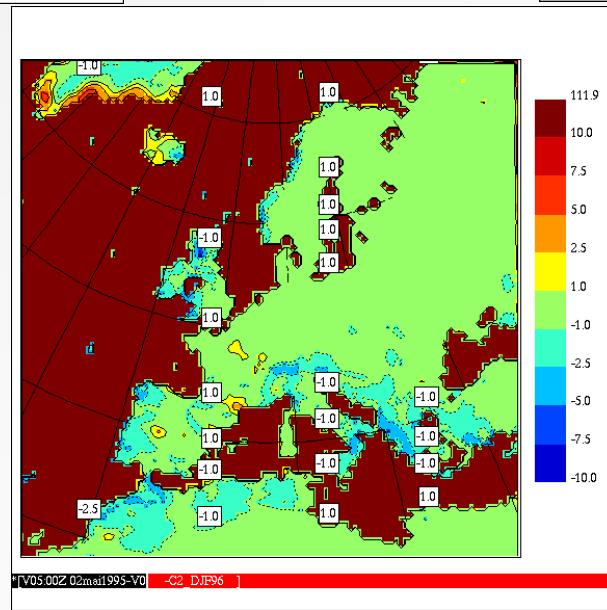
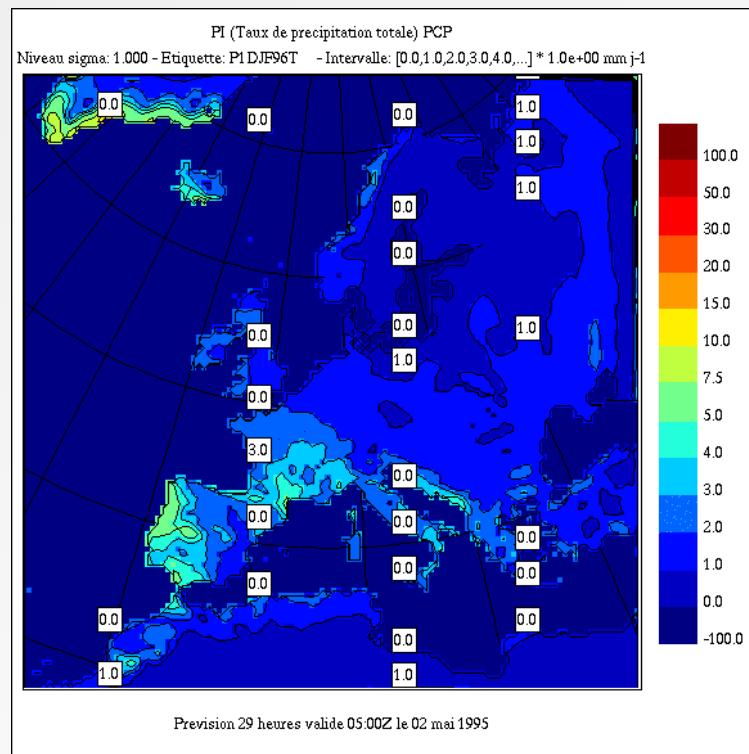
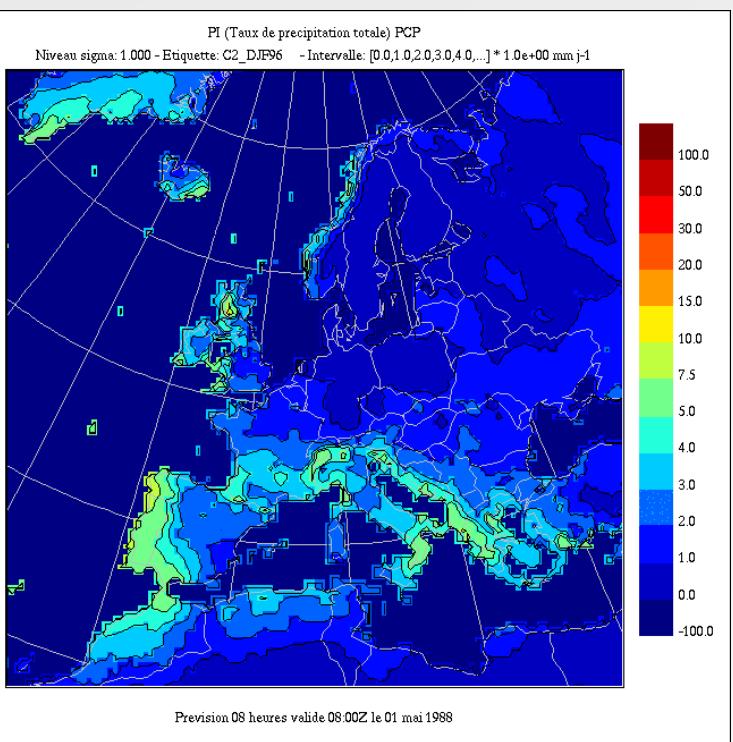
# Le domaine EURO



cru2

DJF 96

mrcc

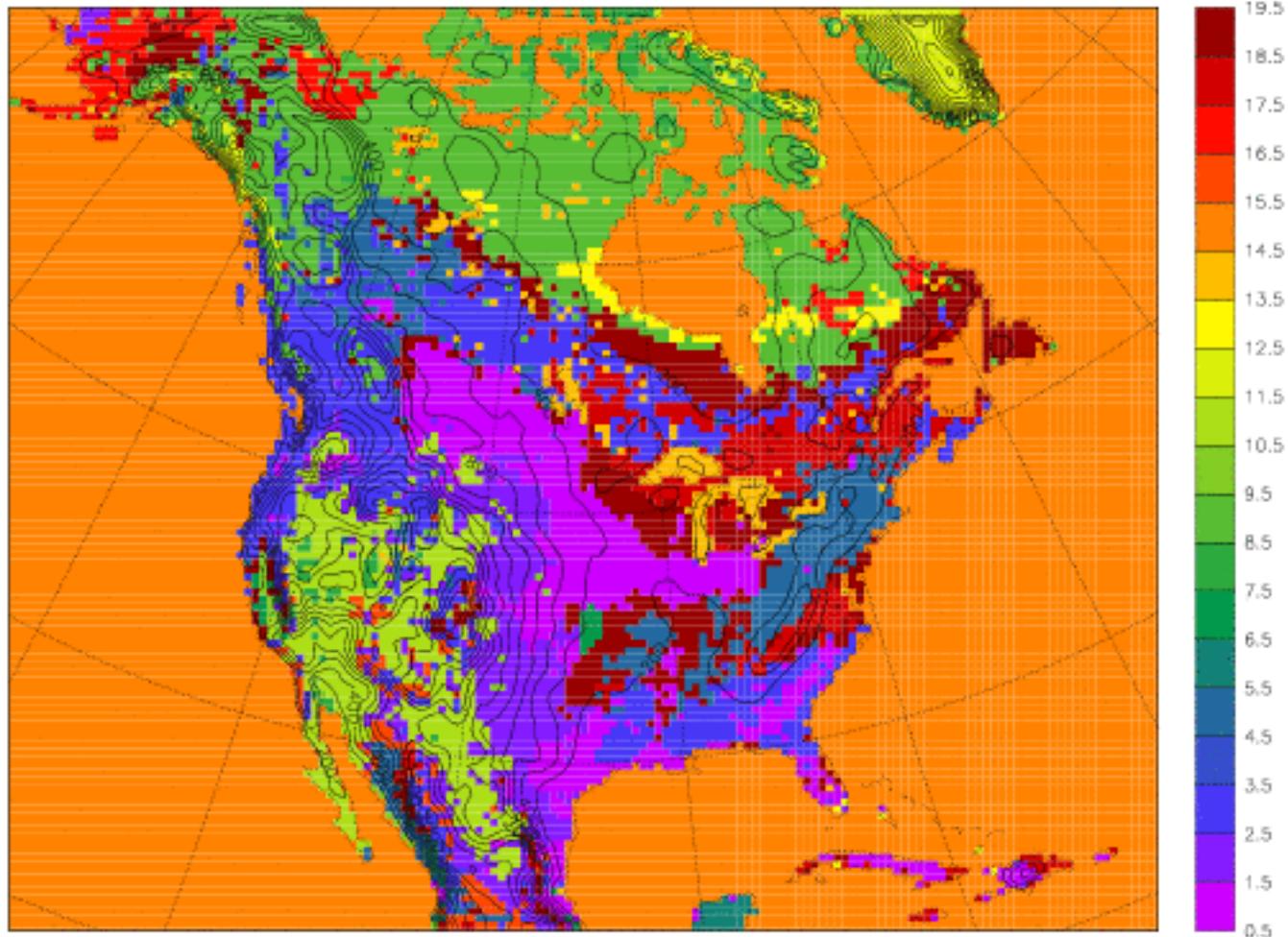


# North American Regional Climate Change Assessment Program (NARCCAP)

- 3 or 4 GCMs to supply boundary conditions
  - NCAR-DOE CCSM; CCCma CGCM3; HadCM3 and HadAM3; GFDL AOGCM
- 5 RCMs over a North-American domain
  - CRCM; MM5; HadRM3; RegCM3; RSM
- 30-year simulations
  - control runs
  - A2-SRES scenario
- Various datasets for model evaluation
  - NCEP/DOE AMIP-II Reanalysis
  - ECMWF

# Domaine NARCCAP

GTOPO30 Topography (m) & GLCC Vegetation



NX=155 NY=130 ds=50km CLAT=47.5 CLON=-97 Mercator